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RDT&E Project No. 1X141806D134-04
USATECOM Project No. 4-4-1542-07
Report No. DPS-2884

FINAL REPORT ON

ENGINEERING TEST

OF

LAUNCHER, XM159/C, FOR ROCKET,

2.75-INCH, LSFFAR

BY

FREDERICK W. BOYLE

OCTOBER 1968

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ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND

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HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-BG
4-4-1542-07

18 NOV 1968

SUBJECT: Final Report on Engineering Test of Launcher, XM159C, for Rocket, 2.75" LSFFAR, RDT&E Project No. 1X141806D134-04

Commanding General
U. S. Army Materiel Command
ATTN: AMCPM-AI

1. References:

a. Letter, AMCPM-AI, 21 November 1967, subject: ET/ST, 2.75" Rocket.

b. Letter, AMSTE-BG, 11 December 1967, subject: Final Report on Integrated ET/ST of XM156 Multiarmament Mount and Safety Evaluation of XM159/A Rocket Launcher.

c. Message, AMCPM-AI, 32658, 16 August 1968, subject: XM160, 2.75" Rocket Launcher.

d. Final Report on Engineering Test of Launcher, XM159/C, for Rocket, 2.75-Inch, LSFFAR, October 1968. (Incl 1)

2. Subject report is approved by this headquarters.

3. Reference 1b forwarded the final report of a safety evaluation conducted on the XM159/A rocket launcher. That report concluded that the XM159/A rocket launcher was safe for use; however, it recommended the electrical contact and detent be redesigned to improve reliability. Several modifications were subsequently made to the launcher including a redesign of the electrical contact; however, no changes were made to the launcher detent. The launcher was redesignated XM159C and subjected to an Engineering Test as requested by reference 1a. This test was conducted by Aberdeen Proving Ground.

4. Significant test results were as follows:

a. Four deficiencies were identified during this test. These deficiencies are as follows:

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SUBJECT: Final Report on Engineering Test of Launcher, XM159C, for Rocket, 2.75" LSFFAR, RDT&E Project No. 1X141806D134-04

(1) The launcher detents broke during the vibration test.

(2) The design of the launcher detent does not insure immediate release of the firing rocket.

(3) The firing-circuit shielding is not connected with any metallic components of the launcher.

(4) The wiring-harness continuity was erratic depending on movement of the firing contact.

b. Four shortcomings were identified during this test. These shortcomings are as follows:

(1) Excessive corrosion occurred on and around the firing contact, and four contacts corroded so that they could not be moved.

(2) The firing contact failed to reliably return to the forward position after firing.

(3) The distance between the firing contact and launcher detent in one tube was too great to provide electrical continuity.

(4) The launcher/rocket combination did not meet the desired accuracy requirements for the 2.75-Inch Rocket. (The 2.75" Rocket has never met this requirement and is considered a shortcoming of the rocket rather than the launcher.)

c. Operational and Maintenance Manuals were not provided with the launchers undergoing test; however, TM 9-1090-204-12 (Mount, Multiarmament, Helicopter: XM156) which includes operational instructions relative to the XM159 launcher was evaluated during the ET/ST of the XM156 Multi-armament Mount (reference 1b) and found to be adequate from the standpoint of the launcher.

d. The XM159C rocket launcher requires limited maintenance. This launcher is reusable; however, it is not repairable. Therefore, there are no spare parts. No maintenance other than normal cleaning of the tubes and lubrication of the spring loaded firing contacts was required.

e. The technical requirements do not state a required level of reliability; however, a reliability assessment of subject launcher is presented in the following table.

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Table - Reliability

Test	No. Rds Fired	No. Misfires	Firing Contact Jammed	Reliability @ 90% Confidence
Environmental	186	10		92%
Endurance	482	16	32	95.5%, 89%[a]
Aerial Firing	109	3		94%
Ground Firing	70	2		93%
Total	847	31	32	95.5%, 92%[a]

[a]Includes firing contact jams as well as misfires.

NOTE: Jammed firing contacts can be returned to the proper position by rapping the aft end of the launcher. The probability of a misfire due to a jammed contact can be reduced by including suitable instructions in the loading procedures for the launchers.

5. The following comments are submitted with respect to the test results:

a. The first two deficiencies represent major problem areas in that a broken detent or a failure to immediately release the rocket will cause a delayed launch. Either occurrence will undoubtedly result in reduced range. This is classified as a major problem area because a reduced range presents a potential safety hazard to friendly ground forces between the aircraft and the target. A special test is being conducted to quantify the effect that a delayed launch has on range; however, this test has not as yet been completed.

b. The other two deficiencies are considered to be minor problem areas. The fact that the firing-circuit shielding is not connected with any of the metallic components of the launcher (reference paragraph 4a(3)) does not mean that the shielding is always ungrounded. The shielding is only ungrounded when the electrical cable between the mount and launcher is not connected. Since the cable is connected prior to flight, the possibility

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of firing a rocket due to induced current is considered to be remote; however, good design would be to ground the shield to the launcher. The erratic electrical continuity experienced during this test (reference paragraph 4a(4)) is attributed to the resistance encountered at the electrical contact due to corrosion. The effect of this loss of continuity is, of course, potential failure to fire a rocket when desired. It was found during this test that exercising the contact prior to loading the launcher was an effective technique for restoring electrical continuity.

c. The three shortcomings associated with the launcher are not considered to be significant problem areas in that the demonstrated degree of reliability is considered satisfactory. However, correction of the shortcomings would further increase the reliability of the launcher.

6. This command is presently coordinating with MICOM as directed in reference 1c in the development of the XM200 rocket launcher which is being developed to replace subject launcher. This effort is presently going forward on an expedited basis. In view of the development of the XM200, it is believed that future development and testing efforts should be concentrated on the XM200 rocket launcher.

7. The conclusions in the report are restated as follows:

The XM159C launcher in its present configuration is not suitable for further test and evaluation.

8. The recommendations in the report are restated as follows:

Further development of the XM159C launcher be suspended pending evaluation of the XM200 launcher.

FOR THE COMMANDER:

Raymond E. Johnson

1 Incl
as
(8 cys)

RAYMOND E. JOHNSON
Colonel, GS
Dir, Avn Mat Testing

18 NOV 1963

AMSTE-BG
SUBJECT: Final Report on Engineering Test of Launcher, XM159C, for Rocket, 2.75" LSFFAR, RDT&E Project No. 1X141806D134-04

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RDT&E PROJECT NO. 1X141806D134-04

USATECOM PROJECT NO. 4-4-1542-07

ENGINEERING TEST OF LAUNCHER, XM159/C, FOR ROCKET, 2.75-INCH, LSFFAR

FINAL REPORT

BY

FREDERICK W. BOYLE

OCTOBER 1968

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND
21005

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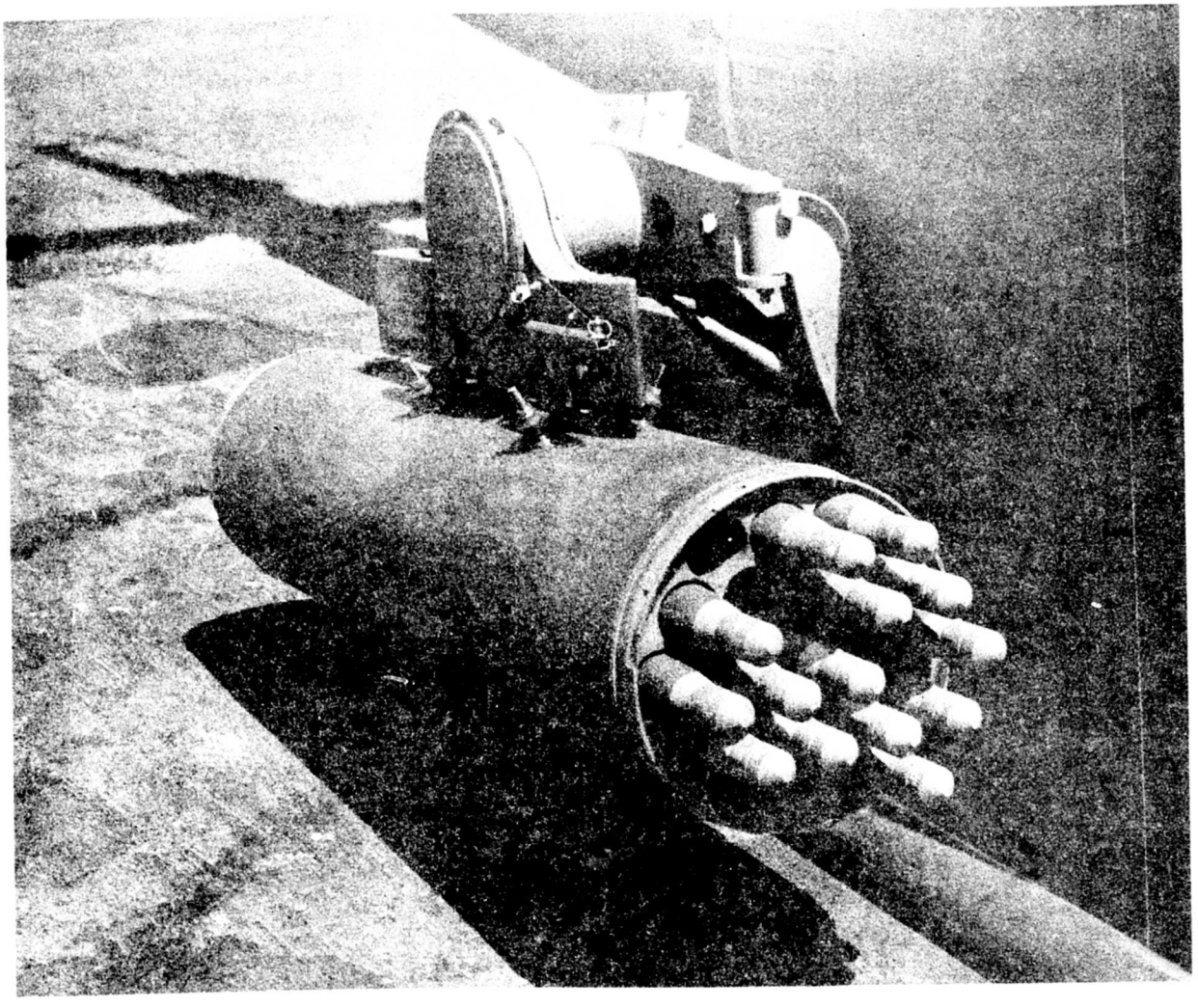
ABSTRACT

The engineering test of the XM159/C rocket launcher was conducted at Aberdeen Proving Ground, Maryland from December 1967 through 16 July 1968. Environmental tests, including simulated helicopter vibration, rain, temperature-humidity, salt spray, sand and dust, and high and low temperature, were conducted. The primary objective of the test was to evaluate the launcher for suitability for use on the UH-1 series helicopter. The test results revealed deficiencies in the electrical firing-circuit design, the ability of the launcher to withstand the aircraft vibration test, and the gas impingement principle of operation of the rocket-motor detent. Shortcomings included excessive corrosion on and about the firing contact, the failure of the firing contacts to reliably return to the forward position after firing, inadequate quality control during manufacturing, and the failure to meet the accuracy requirements. The XM159/C rocket launcher, as designed, is not considered suitable for the intended use. It is recommended that the launcher be improved to correct the deficiencies and shortcoming noted in this report.

FOREWORD

The Materiel Test Directorate, Aberdeen Proving Ground (formerly Development and Proof Services) was responsible for preparing the test plan, conducting the test, and preparing the test report. The simulated helicopter vibration test phase was conducted at Redstone Arsenal due to a heavy workload at APG.



LAUNCHER, XM159/C: LOADED WITH 2.75-INCH LSFFAR ROCKETS, XM229 WARHEADS, AND M423 FUZES

Weight, empty	129.5 lb
Weight, as shown (14 rockets)	529.2 lb
Length	59.8 in.
Diameter	15.5 in.

Data Compiled: July 1967.

Characteristics Photograph

ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

USATECOM PROJECT NO. 4-4-1542-07

FINAL REPORT ON ENGINEERING TEST OF LAUNCHER, XM159/C, FOR ROCKET, 2.75-INCH, LSFFAR

DECEMBER 1967 THROUGH 16 JULY 1968

SECTION 1. INTRODUCTION

1.1 BACKGROUND

To meet a need for additional armament subsystems with a large capacity of 2.75-inch rockets, it was decided to use two XM159, 19-tube rocket launchers with modified components of the XM16/XM21 armament subsystems (XM156) on the UH-1B helicopter.

The initial step in meeting this need, and at the same time, satisfying an urgent requirement for a reuseable launcher for Army helicopter use, was modification of the Air Force POD LAU 3A/A by replacing the paper tubes with aluminum tubes and removing the fairings and intervalometer. The modified launcher was designated the XM159.

The XM159 launcher was subjected to limited testing at Aberdeen Proving Ground and it proved to be only marginally acceptable. However, it was used with the CH-47 aircraft. The results of this testing are reported in firing record No. R-3687.

The XM159 launcher was further modified to increase structural strength and was redesignated the XM159/A launcher.

The improvements incorporated into the XM159/A launcher follows:

a. The launch-tube wall thickness was increased from 0.045 inch to 0.055 inch.

b. The forward and aft bulkhead thickness was increased from 1/4 inch to 3/8 inch.

c. The mass of the electrical contact was increased.

d. All wooden tube separators (internal) were replaced with aluminum separators.

e. The loaded weight of the launcher, as a result of the modification, was increased from 495 pounds to 524 pounds.

The XM159/A launcher was tested at Aberdeen Proving Ground, a safety release issued and a limited production action approved. However, the performance of the launcher was again found to be marginally acceptable. The results of the safety tests are reported in technical report No. DPS-2514.

The initial production test results on the LP XM159/A were essentially the same as those for the XM159/A launcher. These test results are reported in technical report No. DPS-2535.

The launcher has been further improved and is designated the XM159/C.

1.2 DESCRIPTION OF MATERIEL

The XM159/C launcher is a 19-tube reuseable rocket launcher for firing the 2.75-inch LSFFAR. It is an improved version of the XM159/A launcher. The configuration is cylindrical and an aluminum cowling covers the assembly of round aluminum launcher tubes. The tubes are individually wired to allow them to be individually fired. The launcher is attached to the MA4A (14-inch) bomb rack of the XM156 multiarmament mount.

The improvements incorporated into the XM159/C launcher follow:

a. The electrical contact has been replaced with a spring loaded electrical contact.

b. A deflector has been placed in each tube to align and prevent the fins of the rocket from striking the electrical contact and detent during loading.

c. The launcher bulkhead has been changed from a solid plate to a 3/8-inch thick laminated section.

d. The internal wiring of the launcher has been decreased from 022 gage to 026 gage.

e. The launcher length was increased from 49.87 inches to 59.8 inches.

The general characteristics of the XM159/C launcher are as shown in Table 1.2-I.

Table 1.2-I. General Characteristics

Characteristic	Configuration	
	Packaging	Flight
Length, over-all, in.	63.8	59.83
Cross section, in.	18 by 18.5	15.5 diam
Weight, lb		
Empty	188.5	129.25
Loaded	Not applicable	
19, M151 warheads	Not applicable	529.5
14, XM229 warheads	Not applicable	529.2

1.3 TEST OBJECTIVE

The test objective was to evaluate the large capacity XM159/C launcher, 2.75-inch rocket, for suitability as an armament subsystem on the UH-1B helicopter.

1.4 SUMMARY OF RESULTS

All 14 rocket motor detents in the launcher failed, while loaded with rockets assembled with XM229 warheads, during the aircraft vibration test. Three of the 19 detents in the launcher failed during aircraft vibration while loaded with rockets assembled with M151 warheads. The technical requirements were not met and the failures are classified as a deficiency.

The firing-circuit shielding was not connected to any metallic components of the launchers. The technical requirement was not met and this finding is classified as a deficiency.

The launcher wiring-harness continuity was erratic, depending on movement of the firing contacts. Resistance measurements of the firing circuit varied from less than one ohm to infinity. The technical requirement was not met and the finding is classified as a deficiency.

The design of the rocket detent in the launcher does not insure proper release of the firing rocket. Also, a broken detent can jam the rocket in the tube. This finding constitutes a potential safety hazard and is classified as a deficiency.

Excessive corrosion occurred on and around the launcher firing contacts and four contacts of the 19 in one launcher corroded to such an extent that they could not be moved. The technical requirement was not met and the finding is classified as a shortcoming.

The firing contacts of the launcher failed to return to the forward position 32 times during the endurance firing of 482 rounds. None of the technical requirements apply to this finding. This finding is classified as a shortcoming.

The distance between the firing contact and the rocket detent in one tube of one launcher was too great (1/8-inch more than in any other tube) to provide electrical continuity to the rocket. None of the technical requirements apply. This finding is classified as a shortcoming.

The launcher, when firing rockets assembled with M151 warheads, did not meet the technical requirement for accuracy; this finding is classified as a shortcoming.

1.5 CONCLUSIONS

It is concluded that:

a. The performance of the launcher, provided for this test, was unsatisfactory as is indicated by the failure of the launcher to meet 9 of the 26 technical requirements (ref Appendices II and III).

b. The number and type of deficiencies (nongrounding of firing-circuit shielding and unsatisfactory rocket-detent design) experienced in this test of the launcher precludes recommendation of a safety release (ref par. 2.7).

c. The launcher, as designed, is not ready for service test.

d. Testing of the launcher in actual environmental extremes is not required at this time.

1.6 RECOMMENDATIONS

It is recommended that:

a. The launcher be improved to correct the deficiencies and shortcomings noted in Appendix III.

b. No changes be made in the technical requirements at this time.

c. Four improved launchers be provided for confirmatory test.

d. The firing contact and the rocket-motor detent be developed further.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

This test was designed to determine quantitatively the performance and operating characteristics of the rocket launchers. The launchers were evaluated against the Qualitative Materiel Requirements for Armed helicopter weapon systems, 24 October 1962, and the Technical Requirements (for the XM158, seven-tube, reuseable launcher), Revision No. 2, 6 July 1965 where applicable. Emphasis was placed on the safety and functioning aspects of the launcher throughout the flight envelope of the aircraft.

The engineering test of the XM159/C was combined with the initial production test of the XM157/B and XM159/C launchers by authority of letter, AMSTE-BG, 29 November 1967, Appendix V.

Four XM159/C launchers were provided for the tests. As a result of detent failures experienced during the vibration test, USAMICOM personnel provided two additional launchers with modified detents. The modified launchers were vibrated and fired as a part of the initial production test, however, the results were not satisfactory (Reference 8). The results of the initial production test are contained in Reference 7.

2.2 PHYSICAL CHARACTERISTICS

2.2.1 Objective

The objective was to determine the basic physical data on the launcher for comparison with stated technical requirements.

2.2.2 Criteria

Criteria are as follow:

a. Flight Weight. One complete reuseable 19-tube launcher shall not weigh more than 130 pounds. (TR-XM158, par. 3.1.2.5.)

b. Configuration. The 19 tubes shall be clustered in a minimum volume package which shall be essentially cylindrical. (TR-XM158, par. 2.1.2.6.)

c. Electrical Design. The electrical design will be in conformance with MIL-M-11991B. (TR-XM158, par. 3.1.2.3.)

d. Electrical Power Requirements. Electrical power for firing rockets and jettisoning shall be drawn from the aircraft 24- to 28-volt d-c system under operational conditions. (TR-XM158, par. 3.1.2.8.)

e. Attachment. The reuseable 19-tube launcher shall be capable of being attached to the MA-4A bomb rack. The external electrical plug shall be set in line with the launcher bomb-rack eye hooks on the launcher fore end where bomb-rack sway braces and launcher external wiring will not interfere with each other. The electrical plug shall have a dust cover. (TR-XM158, par. 3.1.2.9.)

f. Sway-Brace Accommodations. Hard-point surfaces to accommodate the use of sway braces shall be provided. These surfaces shall, as a minimum, be compatible with the sway-brace locations of the XM16 subsystem. (TR-XM158, par. 3.1.2.10.)

g. Physical Dimensions. The launcher shall have 19 essentially round tubes which are nominally 58 inches long. The outside diameter of the launcher shall be approximately 15.5 inches. (TR-XM158, par. 3.1.2.12.)

h. Detents. The rocket detent shall not incorporate any item which must be replaced for each rocket firing. The detent shall require a 90-pound minimum force applied before release of the rocket. (TR-XM158, par. 3.1.2.13.)

i. Combustible Material. A minimum of combustible material shall be used in the launcher construction. Any combustible material shall have a minimum of exposure to the rocket-blast fire and hot gases and shall be treated with fire-retardant chemicals so no burning or smoldering will occur. (TR-XM158, par. 3.1.2.14.)

j. Firing Order. The armament system fire-control arrangement and wiring to be used with the reuseable 19-tube launcher and the wiring of the launcher itself shall be such that rockets are not fired successively from adjacent tubes. (TR-XM158, par. 3.1.2.17.)

k. Grounding of External Launcher Parts. The design and construction shall insure that all external launcher parts exclusive of transmission-line terminals are at ground potential at all times in accordance with ABMA-STD-54C. (TR-XM158, par. 3.1.2.23.)

l. Wiring. The wire shall be type E shielded and teflon-jacketed in accordance with MIL-S-16878/4A. (TR-XM158, par. 3.1.2.19.)

m. Shielding. All firing circuits contained in the launcher shall be shielded. All shields shall be connected and grounded. The shields shall make contact with the metallic components of the launcher. (TR-XM158, par. 3.1.2.14.)

n. Packaging. The reuseable launcher shall not be used for transportation or storage of rockets. (TR-XM158, par. 3.1.2.21.)

0. Tools. Special tools shall not be required for maintenance of the reuseable 19-tube launcher. (TR-XM158, par. 3.1.2.20.)

2.2.3 Method

The mechanical and electrical characteristics of the launcher are examined, when received and after firing tests, photographed, and described. Weights and measures to include trammel points, straightness lines, and star-gage records, are obtained and recorded. Appropriate parts of rocket launcher tests procedures, Test and Evaluation Command Procedures 700-700, Interim Pamphlet 40-20, are used for evaluation purposes.

2.2.4 Results

The following results were obtained:

a. The launcher is 15.5 inches in diameter and 59.8 inches long.

b. The empty launcher weighs 129.5 pounds.

c. Straightness and star-gage measurements are contained in References 2 and 3. No significant changes were observed.

d. The launcher is capable of carrying the 2.75-inch LSFFA rocket with the M151 warhead or the XM229 warhead. Weight considerations limit the launcher to a maximum load of 14 motors with XM229 warheads or 19 motors with M151 warheads.

e. The launcher was fired using the XM156 mount. The system power requirements from the helicopter were 24 to 28 volts, 4.5 amps (stand-by) and 7.0 amps (firing).

f. The center of gravity, measured in inches from the aft end, was as shown in Table 2.2-I.

Table 2.2-I. Center of Gravity Measurements, inches measured from aft end

Empty	19 Motors M151 Warheads M423 Fuzes	14 Motors XM229 Warheads M423 Fuzes
28.85	32.72	37.32

g. The required operating equipment **includes an XM156 multi-**armament mount, a power supply, and a firing switch.

h. The forward force required to release the rocket from the tube detent was in excess of 200 pounds in each tube.

i. The maximum electrical potential of the launcher, measured after spraying with a 5% salt water solution, was 0.80 volts across an open circuit. Less than 10 millivolts and 10 milliamps were measured across an 0.76-ohm resistor.

j. The maximum open-circuit-induced voltage was obtained with the helicopter engine running and the transmitter on. The voltage was 0.04 volts. **The corresponding maximum current across an 0.76-ohm resistor was 35 milliamps.**

k. **An examination of the firing circuit indicated that the shielded cables were not connected with the metallic components of the launcher, but instead were connected to pin c of the electrical plug.**

2.2.5 Analysis

The objective of this subtest was achieved. The failure of the firing-circuit shielding to be connected to the metallic components of the launcher is classified as a deficiency. All other results are considered satisfactory.

2.3 ACCELERATION AND VIBRATION

2.3.1 Objective

The objectives were:

a. To determine the safety aspects of the launcher empty, partially filled, and completely loaded when subjected to forces of acceleration, shock, and vibration at high, ambient, and low temperatures.

b. To determine the ability of the launcher to withstand the g loads specified in the technical requirements.

2.3.2 Criteria

Criteria were as follow:

a. Acceleration and Vibration. The 19-tube launcher shall be serviceable during and after being repeatedly subjected to g factors, shock, and vibration when attached to the XM156 multiarmament mount and subsystem support structure of the UH-1B helicopter, and while in both flight and ground environments. This applies to launchers that are empty, partially filled, and completely filled with 2.75-inch rockets. (TR-XM158, par. 3.1.2.7.)

b. G Loads. The launcher, including the bomb-rack attachments and sway-brace surfaces, loaded with 19 rockets weighing as much as 21.5 pounds each, shall be designed to withstand accelerations of at least 4 g's forward, 5 g's downward, 2 g's upward, and 1.5 g's laterally, each applied individually. The launcher shall also be designed to withstand combined acceleration loads of at least 3.6 g's downward, 1.82 g's aft, or 1.82 g's forward, and 0.62 g inboard or 0.62 g outboard. (TR-XM158, par. 3.1.2.11.)

c. Firing Rate. The launcher shall be capable of withstanding a firing rate of approximately six rounds per second. (TR-XM158, par. 3.1.2.16.)

d. Metals. Metals shall be of the corrosion-resistant type or suitably treated to resist corrosion resulting from rocket blast, fuels, salt spray, or atmospheric conditions likely to be met in storage or normal service. (TR-XM158, par. 3.1.2.4.)

e. General. The contents and requirements contained in the Ordnance Safety Manual AMC-R-385-24, all references therein, and the latest revisions thereto, shall be considered a mandatory part of the design criteria for the equipment developed under this technical requirement. (TR-XM158, par. 3.1.2.23.)

f. General reliability of the XM159/C launcher shall be at least commensurate with MIL-E-11991B and MIL-A-8591B. (TR-XM158, par. 3.1.5.)

g. The peak and steady-state currents required by the test items, when added to the normal aircraft electrical system, shall not exceed the capability of the aircraft primary electrical system. (Devised by D&PS.)

2.3.3 Method

The XM156 multiarmament mount for the right side and an XM159/C launcher, loaded with 14 inert 2.75-inch rockets with XM229 warheads and M423 fuzes are vibrated in accordance with the procedures outlined in MIL-STD-810, method 514, at low, ambient, and high temperatures, respectively. A resonance search in each axis with one round at a time being removed is conducted to determine the worst vibration load condition. The tests are conducted under the worst load conditions.

The XM156 mount for the left side (rack and support assembly) and a launcher are mounted on a test stand, loaded with inert rockets, and subjected to gravity forces forward, rearward, downward, and laterally. Rockets are inert-loaded with a high-density material to simulate the gravity forces stated in the criteria, paragraph b. After removal of the load, the straightness lines and trammel points are examined for changes (deformation) and the bore sight checked for permament displacement.

At the completion of the above tests, the test items are returned to ambient temperature, mounted on a UH-1B helicopter and the launchers ripple ground-fired using inert warhead rockets (19 rounds from each mount and launcher).

2.3.4 Results

The designated launcher was loaded with 14 inert-loaded rockets with XM229 warheads and M423 fuzes. After 1 hour and 15 minutes of vibration in the longitudinal plane, at ambient temperature, the rocket detent in each loaded tube had been broken. The launcher was returned to the contractor by USAMICOM personnel for an analysis of the failures.

A second XM159/C launcher was sent to Redstone Arsenal and vibrated with 19 inert-loaded rockets with M151 warheads and M423 fuzes. After three hours of vibration in the longitudinal plane, at ambient temperature, three rocket detents had been broken. The three tubes with broken detents had previously fired the following numbers of rockets: 111, 112, and 12. An inspection of the launcher upon return to APG revealed a fourth broken detent lying loose in the tube. Excessive corrosion was observed on and around the firing contacts and four contacts were corroded so that they could not be moved.

The wiring-harness resistance and continuity measurements were very erratic depending on the movement of the firing contacts.

Details of the vibration test are contained in Reference 4.

2.3.5 Analysis

The objectives of this subtest were achieved; however, the results are not considered satisfactory. The detent failures are classified as a deficiency and the excessive corrosion and erratic electrical continuity are classified as shortcomings.

2.4 ENDURANCE

2.4.1 Objective

The objective was to determine performance, reliability, and durability of the launcher.

2.4.2 Criteria

Criteria were as follows:

a. The XM159/C launcher shall be capable of firing a minimum of 25 (35 desired) rounds from each launcher tube without parts or tube replacement. (Ltr, AMCPM-AI, 19 Jan 67.)

b. The launcher shall be compatible with 2.75-inch folding-fin aircraft rockets having the standard warhead M151 (10-pound) and the M423 fuze. The launcher shall be compatible with the XM156 system. (TR-XM158, par. 3.1.4.)

2.4.3 Method

A launcher is attached to a test stand and 100 rounds are ground-fired from each of three launcher tubes. The three tubes are randomly selected. Also, ten rockets are fired from each of the remaining 16 tubes. Loading of the rocket into the launcher tube is accomplished by orienting the fin to strike the fin deflector.

2.4.4 Results

Tubes 4, 6, and 11 each fired 110 rockets during the endurance test. In 32 instances, the firing contact in one of the three tubes was jammed in the rearward position after firing and required a sharp rap before the spring could return it to the forward position. Two misfires occurred during the firing of the three tubes. One misfire was the result of the firing contact not being returned to the forward position. The other rocket was successfully fired after the firing contact was moved back and forth a few times.

One of the remaining 16 tubes fired only two rockets in seven attempts. The other 15 tubes fired 10 rockets each with a total of 8 misfires.

In all cases of a misfire, the rocket was successfully fired when placed in another tube.

The launcher did not appear to be damaged in any way after the endurance firing and star-gage, straightness, and alignment measurements indicated no significant changes as a result of the firing.

2.4.5 Analysis

The objective of this subtest was achieved. The failure of the firing contact to reliably return to the forward position and the excessive number of misfires are classified as shortcomings.

2.5 AERIAL FIRING

2.5.1 Objectives

The objectives were:

a. To determine the compatability of firing the XM159/C launcher from the UH-1B helicopter using the XM156 armament subsystem.

b. To evaluate the performance of the XM159/C launcher in comparison with the XM3 rocket launching subsystem when firing the same type 2.75-inch rockets.

2.5.2 Criteria

The launcher must fire rockets to a range of 3000 meters, have a circular error probable (CEP) of 50 meters at 2000 meters and all rounds in a ripple must fall within a 300-meter circle. (QMR, par. 7d(2).)

2.5.3 Method

The performance of the launcher and the effectiveness of the safety devices are evaluated by firing rocket ammunition from the helicopter in ground operation and air operation at the conditions shown in Table 2.5-I.

Table 2.5-I. Firing Schedule

Group	Helicopter Conditions: Speed	Altitude Absolute, ft	Range, meters	Launcher Elev, degrees	Ammunition 2.75-In. Rocket: No. Rds	Warhead Type	Type Firing
Operation: Ground.							
1	0	0	-	15	24	M151 HE	Single round.
2	0	0	-	30	12	M151 HE	Single round.
Operation: Air.							
3	0	10	500		24	M151 inert	One ripple (seven rounds each side) and five pairs.
4	Medium	100	1000		50	M151 inert	One ripple (seven rounds each side) and 18 pairs.
5	0	100	2000		24	M151 inert	One ripple (seven rounds each side) and five pairs.
6	Medium	100	2000		50	M151 inert	One ripple (seven rounds each side) and 18 pairs.
7	Maximum	100	2000		24	M151 inert	One ripple (seven rounds each side) and five pairs.
8	Maximum	100	3000		24	M151 inert	One ripple (seven rounds each side) and five pairs.

Totals: 2.75-inch rocket with warhead and fuze contingency 232
18
250

The helicopter is inspected after each firing, with particular emphasis on the tail rotor, to determine if rocket debris damages any part of the aircraft.

2.5.4 Results

A total of 109 rockets was successfully fired in single-pair bursts in accordance with Table 2.5-I. The ripple-firing phase (seven pairs per burst) was postponed due to weather conditions and finally cancelled as a result of detent failures encountered during the vibration test. Three misfires were observed during the aerial firing test.

A total of 70 rockets was fired from a ground-test fixture. Two rounds misfired on the first attempt, but were fired successfully on the second attempt. The 15° elevation firings were repeated, using XM429 proximity fuzes to insure adequate ballistic data.

No damage to the aircraft was observed.

A summary of the ballistic data is contained in Appendix I. The launchers did not meet the CEP requirement of 50 meters at 2000 meters.

2.5.5 Analysis

The objectives of this subtest were only partially achieved. The failure of the launcher to fire rockets at 2000 meters with a CEP of 50 meters is classified as a shortcoming.

2.6 ENVIRONMENTAL TESTS

2.6.1 Objective

The objective was to determine the capability of the launcher to withstand and operate in various types of environment.

2.6.2 Criteria

Criteria were as follows:

a. The reusable 19-tube XM159/C launcher shall meet all the climatic design criteria of AR 705-15 with Change 1, with the exception of paragraph 7e, Extreme Cold Climatic Conditions. (TR-XM158, par. 3.1.2.)

b. Human factors design criteria shall conform to specifications on human factors. The design shall be compatible with the use of arctic mittens. (TR-XM158, par. 3.1.2.2.)

c. All metals shall be of the corrosion-resistant type or suitably treated to resist corrosion resulting from rocket blast, fuels, salt spray, or atmospheric conditions likely to be met in storage or normal service. (TR-XM158, par. 3.1.2.4.)

d. No seals will be required to protect the XM159/C launcher against the applicable environmental conditions of AR 705-15, with Change 1, during transportation, storage, and service use. (TR-XM158, par. 3.1.2.22.)

e. The peak and steady-state currents required by the test items, when added to the normal aircraft electrical system, shall not exceed the capability of the aircraft primary electrical system (devised by D&PS).

2.6.3 Method

2.6.3.1 High Temperature. One launcher with a full compliment of rockets was tested in accordance with MIL-E-5272, Procedure II, except that the maximum temperature was +155°F. The wiring-harness resistance and continuity was checked and the launcher was fired at +155°F. It was returned to +125°F for an additional four hours, then checked and fired again.

2.6.3.2 Low Temperature. One launcher with a full compliment of rockets was tested in accordance with MIL-E-5272, Procedure I. The wiring-harness resistance and continuity were checked and the launcher was fired at -65°F. The launcher was returned to -40°F for an additional four hours, then checked and fired again.

2.6.3.3 Dust Test. One launcher was operationally checked, then subjected to sand-and-dust densities of 0.1 to 0.5 grams per cubic foot at +77°F for two hours and at +160°F for two hours duration. The air velocity was maintained at 100 to 500 fpm and the relative humidity within the cabinet did not exceed 30%. After exposure to the environment, the wiring-harness resistance and continuity were checked and the launcher was loaded and ripple-fired.

2.6.3.4 Humidity Test. Two launchers were operationally checked, then subjected to the temperature-humidity environment in accordance with MIL-E-5272, Procedure III. At the conclusion of the test, the launchers were given a continuity check and the resistance in the firing circuits was measured. The launchers were then loaded and ripple-fired.

2.6.3.5 Rain Test. Two launchers were operationally checked, then subjected to a simulated rain-storm environment in accordance with MIL-E-5272, Procedure II. Immediately following the exposure the wiring-harness resistance and continuity were checked, and the launchers were loaded and ripple fired.

2.6.3.6 Salt Spray. One launcher was operationally checked, then subjected to a salt-fog environment in accordance with MIL-STD-810B, Method 509, Procedure I. Immediately following the exposure the wiring-harness resistance and continuity were checked and the launcher was loaded and ripple fired.

2.6.4 Results

2.6.4.1 High Temperature. All rockets fired properly on the first attempt and no operational difficulties were observed.

2.6.4.2 Low Temperature. All rockets fired properly on the first attempt and no operational difficulties were observed.

2.6.4.3 Dust Test. No operational difficulties, attributable to the sand-and-dust environment, were observed. Two misfires occurred while ripple-firing the launcher. The electrical contacts appeared satisfactory and a simulated firing indicated that adequate pulses were present. The two rockets were replaced in the respective tubes and they again misfired. The rockets were placed in two other tubes and were fired on the first attempt.

2.6.4.4 Humidity Test. The wiring-harness resistance and continuity measurements were erratic depending on movement of the firing contacts. A total of 38 rockets was successfully fired from the launchers. Five rockets failed to fire on the first attempt, but did fire after the firing contact was moved back and forth to improve electrical continuity.

2.6.4.5 Rain Test. No operational difficulties, attributable to the torrential rain exposure, were observed. One rocket failed to fire on the first attempt. An examination of the electrical contact indicated that the distance between the rocket-motor detent and the spring-loaded firing contact was too great to provide electrical continuity to the rocket-firing squib. A shunt was inserted and the rocket was fired.

2.6.4.6 Salt Spray. The launcher was severely corroded by the salt-fog atmosphere as illustrated by Figure 2.6-1. All measurements of wiring-harness resistance and continuity were erratic due to short circuiting caused by the salt deposits and high resistance caused by the corroded firing contacts. Any movement of the firing contacts resulted in widely varying resistance readings. One misfire occurred while ripple-firing the launcher. The electrical contact was exercised and the rocket fired on the second attempt.

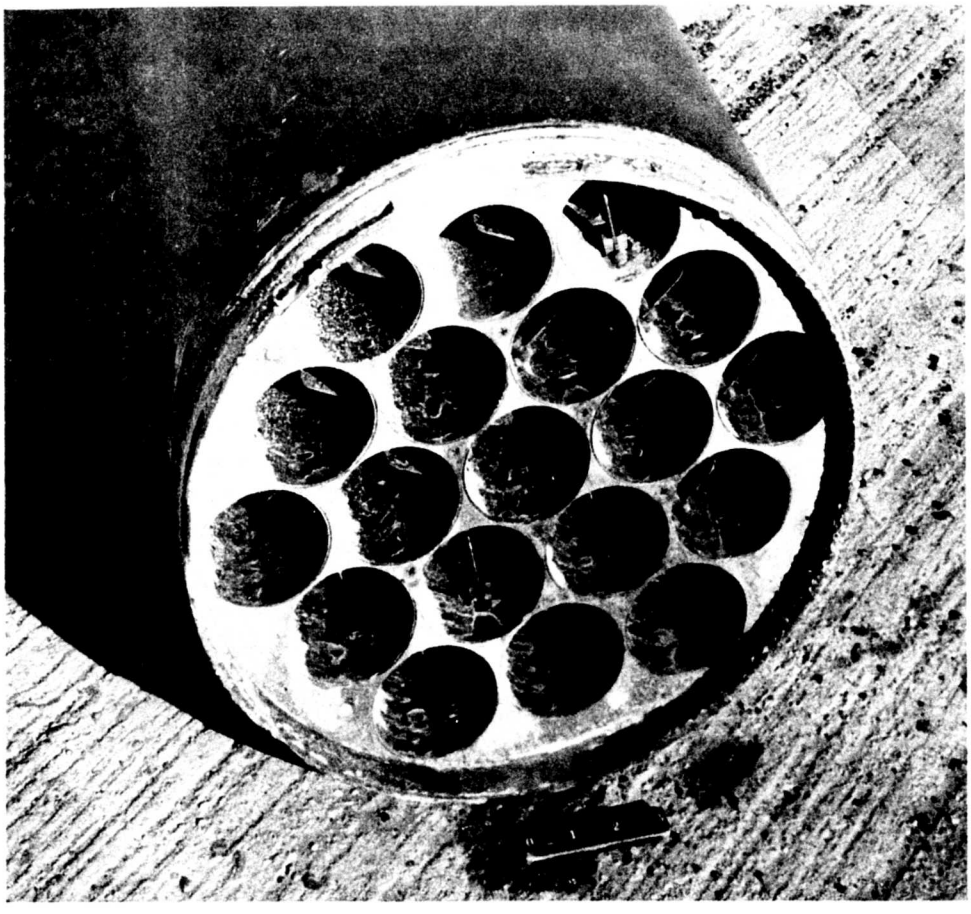


Figure 2.6-1: Aft End of XM159/C Launcher After Salt-Spray Environment.

2.6.5 Analysis

The objective of this subtest was achieved; however, the results were not satisfactory. The erratic nature of the wiring-harness resistance and continuity **resulted in misfired rockets and is considered a deficiency. The excessive distance between the firing contact and** the rocket-motor detent in one tube is considered a shortcoming.

2.7 SAFETY

2.7.1 Objective

The objective was to determine the safety of the XM159/C rocket launcher.

2.7.2 Criteria

The XM159/C rocket launcher must complete all phases of testing without exhibiting one unsafe condition.

2.7.3 Method

The test item is observed throughout all testing and records are kept on any safety hazard and potential safety hazards.

2.7.4 Results

The design of the rocket detent does not insure immediate release of the firing rocket. During a related aerial firing test of an XM157/B rocket launcher (which has the same detent and tube assembly), a delayed rocket release was observed. An inspection of the launcher tube revealed two holes in the aft end which were caused by the delayed release, References 6 and 7.

Notes: Reliable rocket release is contingent upon all four rocket-nozzle closures (caps) being blown out at the same time. Such a condition does not exist.

Rocket detents, broken during vibration, have jammed the rocket in the tube so that, if the rocket were fired, it would not be immediately released from the tube (Reference 7).

A delayed rocket release results in a potential safety hazard to the crew members aboard the aircraft and also to friendly ground forces between the aircraft and the target (due to the shortened range).

The firing-circuit shielding is not connected to the metallic components of the launcher. This condition enables the rocket motors to be fired by induced current if the electrical cable between the XM156 mount and the launcher is not connected.

The firing-circuit does not maintain continuity at all times due to the ineffective design of the firing contact. When continuity does not exist, the rocket firing squib is not shorted and is subject to being fired by induced current.

2.7.5 Analysis

The objective of this subtest was achieved. The possibility of a delayed rocket release is classified as a design deficiency.

The ungrounded firing-circuit shielding is classified as a deficiency due to the possibility of firing the rocket motors by induced current.

The failure of the firing circuit to maintain continuity is classified as a deficiency due to the potential safety hazard.

2.8 ELECTRICAL LOAD CHARACTERISTICS

2.8.1 Objectives

The objectives were:

a. To determine that the electrical load requirements of the XM159/C launcher system is compatible with the electrical capabilities of the aircraft.

b. To provide data for evaluation of the test items during environmental tests.

2.8.2 Criteria

The peak and steady-state currents required by the test items, when added to the normal loads imposed on the aircraft electrical system, shall not exceed the capability of the aircraft primary electrical system.

2.8.3 Method

The electrical load requirements of the test items is measured in both standby and operating conditions during the laboratory, flight, and simulated environmental tests. Standard voltage and current measuring instruments are used.

The sum of all power-consuming equipment is compared to the capability of the aircraft primary electrical system. The effects of various environments on the load required by the armament subsystem are evaluated.

2.8.4 Results

The steady-state current drawn by the XM156 mount and the XM159/C launcher under standby and operating modes were 4.5 amps and 7.0 amps respectively. No peak current was observed.

No significant voltage fluctuations in the aircraft electrical system were caused by operation of the launcher system.

The aircraft power generator is capable of producing 300 amps; however, except while starting the engine, the power requirements are less than 100 amps.

2.8.5 Analysis

The objective of this subtest was achieved and the results are considered satisfactory. The electrical capability of the aircraft primary electrical system is not exceeded as a result of operating the launcher system.

SECTION 3. APPENDICES

APPENDIX I - TEST DATA

Round-by-Round Data

Ripple No.	Rd No.	Tube No.[a]	Remarks
		High-Temperature Test	
Conditioning Temperature: +155°F.			
Date Fired: 26 January 1968.			
Launcher: XM159/C No. 3C.			
Mount: XM156, left side (comparison test).			
Ammunition: Mk 40 motor, M151 warhead (inert-loaded), M423 fuze (inert-loaded).			
Time Fired: 0945.			
1	[b] 1	1	
	2	4	
	3	5	
	4	2	
	5	3	
	6	7	
	7	6	
2	8	18	
	9	13	
	10	16	
	11	11	
	12	12	
	13	9	
	14	14	
3	15	15	
	16	10	
	17	17	
	-	8	Empty, broken detent.
	18	19	
Conditioning Temperature: +125°F.			
Time Fired: 1520.			
5	26	1	
	27	4	
	28	5	
	29	2	
	30	3	

[a]Tube number is determined by firing order on right-hand XM156 mount.
[b]Prior to this test, one round was fired from tubes 15, 18, and 19.

Ripple No.	Rd No.	Tube No.	Remarks
	31	7	
	32	6	
6	33	18	
	34	13	
	35	16	
	36	11	
	37	12	
	38	9	
	39	14	
	40	15	
	41	10	
	42	17	
	-	8	Empty, broken detent.
	43	19	

Low-Temperature Test

Conditioning Temperature: -65°F.
Date Fired: 29 January 1968.
Time Fired: 1020.

9	51	1	
	52	4	
	53	5	
	54	2	
	55	3	
	56	7	
	57	6	
10	58	18	
	59	13	
	60	16	
	61	11	
	62	12	
	63	9	
	64	14	
11	65	15	
	66	10	
	67	17	
	-	8	Empty, broken detent.
	68	19	

Conditioning Temperature: -40°F.
Time Fired: 1520.

13	76	1	
	77	4	
	78	5	

Ripple No.	Rd No.	Tube No.	Remarks
	79	2	
	80	3	
	81	7	
	82	6	
14	83	18	
	84	13	
	85	16	
	86	11	
	87	12	
	88	9	
	89	14	
15	90	15	
	91	10	
	92	17	
	-	8	Empty, broken detent.
	93	19	

Rain-Test Firing

Ripple No.	Rd No.	Tube No. 1C	Tube No. 2C	Remarks
Date Fired: 30 January 1968.				
Launchers: XM159/C Nos. 1C and 2C.				
Mount: XM156, right side (comparison test).				
Ammunition: Mk 40 motor, M151 warhead (inert-loaded), M423 fuze (inert-loaded).				
Time Fired: 1510.				
17	101	1		
	103	2		
	105	3		Misfire. Examination indicated that the firing contact was not touching the rocket firing squib. A shunt was inserted and the rocket fired.
	107	4		
	109	5		
	111	6		
	113	7		
18	115	8		
	116	9		
	117	10		
	118	11		
	119	12		
	120	13		

Ripple No.	Rd No.	Tube No. 1C	Tube No. 2C	Remarks
	121	14		
19	122	15		
	123	16		
	124	17		
	125	18		
	126	19		
Time Fired: 1530.				
20	127		1	
	129		2	
	131		3	
	133		4	
	135		5	
	137		6	
	139		7	
21	141		8	
	142		9	
	143		10	
	144		11	
	145		12	
	146		13	
	147		14	
22	148		15	
	149		16	
	150		17	
	151		18	
	152		19	

Sand-and-Dust Test Firing

Ripple No.	Rd No.	Tube No.	Remarks
Date Fired: 2 February 1968.			
Launcher: XM159/C No. 4C.			
Mount: XM156, right side (comparison test).			
Ammunition: Mk 40 motor, M151 warhead (inert-loaded), M423 fuze (inert-loaded).			
Time Fired: 1530.			
23	153	1	
	154	4	Misfire. Electrical contact appeared satisfactory. Second attempt misfired. Electrically checked satisfactory. Fired rocket from tube 1.

Ripple No.	Rd No.	Tube No.	Remarks
	155	5	
	156	2	
	157	3	
	158	7	
	159	6	
24	160	18	
	161	13	
	162	16	Misfire. Electrical contact appeared satisfactory. Second attempt misfired. Electrically checked satisfactory. Fired rocket from tube 3.
	163	11	
	164	12	
	165	9	
	166	14	
25	167	15	
	168	10	
	169	17	
	170	8	
	171	19	

Salt-Spray Test Firing

Ripple No.	Rd No.	Tube No. 4C	Remarks

Date Fired: 5 February 1968.
Launcher: XM159/C No. 4C.
Mount: XM156, right side.
Ammunition: Mk 40 motor, M151 warhead (inert-loaded), M423 fuze (inert-loaded).
Time Fired: 1505.

27	179	1
	180	2
	181	3
	182	4
	183	5
	184	6
	185	7
28	186	8
	187	9
	188	10
	189	11
	190	12

Ripple No.	Rd No.	Tube No. 4C	Remarks
	191	13	Misfire. Removed rocket and checked firing pulse-satisfactory. Fired on second attempt.
	192	14	
29	193	15	
	194	16	
	195	17	
	196	18	
	197	19	

Endurance Firing

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
Date Fired: 6 February 1968.				
Launcher: XM159/C No. 4C.				
Mount: XM156, right hand side only.				
Ammunition: Mk 40 motor, M151 warhead (inert-loaded), M423 fuze (inert-loaded).				
31	205	1	1050	
	206	2		Misfire.
	207	3		Misfire.
	208	4		
	209	5		
	210	6		
	211	7		
32	212	8		
	213	9		
	214	10		
	215	11		
	216	12		
	217	13		
	218	14		
33	219	15		Misfire.
	220	16		
	221	17		
	222	18		Misfire.
	223	19		
34	224	1	1052	Misfire.
	206	2		
	207	3		
	225	4		
	226	5		

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
	227	6		
	228	7		
35	229	8		
	230	9		
	231	10		
	232	11		
	233	12		
	234	13		
	235	14		
36	219	15		
	236	16		
	237	17		
	222	18		Misfire.
	238	19		
37	224	1	1055	Misfire. Round 224 was removed and loaded into tube 4 and fired in ripple 40. The firing pulse was checked and found to be satisfactory. Tube 1 was reloaded with round 256.
	239	2		
	240	3		
	241	4		
	242	5		
	243	6		
	244	7		
38	245	8		
	246	9		
	247	10		
	248	11		
	249	12		
	250	13		
	251	14		
39	252	15		
	253	16		
	254	17		
	222	18		Misfire. Round 222 was removed and loaded into tube 10 and fired in ripple 41. The firing pulse was checked and found to be satisfactory. Tube 18 was reloaded with round 271.

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
	255	19		
40	256	1	1104	Misfire.
	257	2		
	258	3		
	224	4		
	259	5		
	260	6		
	261	7		
41	262	8		
	263	9		
	222	10		
	264	11		
	265	12		
	266	13		
	267	14		
42	268	15		
	269	16		
	270	17		
	271	18		Misfire.
	272	19		
43	256	1	1110	Misfire. Removed round 256 and loaded it in tube 2 and fired in ripple No. 46. Tube 1 was left empty until ripple No. 236.
	273	2		
	274	3		
	275	4		
	276	5		
	277	6		
	278	7		
44	279	8		
	280	9		
	281	10		
	282	11		
	283	12		
	284	13		
	285	14		
45	286	15		
	287	16		
	288	17		
	271	18		Misfire. Round 271 was removed and loaded into tube 3 and fired in ripple No. 47. Tube 18 was left empty.

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
	289	19		
46	256	2	1116	
	271	3		
	290	4		
	291	5		
	292	6		
	293	7		
47	294	8		
	295	9		
	296	10		
	297	11		
	298	12		
	299	13		
	300	14		
48	301	15		
	302	16		
	303	17		
	304	19		
49	305	2	1123	
	306	3		
	307	4		
	308	5		
	309	6		
	310	7		
50	311	8		
	312	9		
	313	10		
	314	11		
	315	12		
	316	13		
	317	14		
51	318	15		
	319	16		
	320	17		
	321	19		
52	322	2	1130	
	323	3		
	324	4		
	325	5		
	326	6		
	327	7		
53	328	8		
	329	9		
	330	10		
	331	11		
	332	12		
	333	13		

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
	334	14		
54	335	15		
	336	16		
	337	17		
	338	19		
55	339	2	1135	
	340	3		
	341	4		
	342	5		
	343	6		
	344	7		
56	345	8		
	346	9		
	347	10		
	348	11		
	349	12		
	350	13		
	351	14		
57	352	15		
	353	16		
	354	17		
	355	19		
58	356	2	1145	
	357	3		
	358	4		
	359	5		
	360	6		
	361	7		
59	362	8		
	363	9		
	364	10		
	365	11		
	366	12		
	367	13		
	368	14		
60	369	15		
	370	16		
	371	17		
	372	19		
61	373	4	1251	
	374	6		
62	375	11		
63	376	4	1253	
	377	6		
64	378	11		
65	379	4	1255	
	380	6		

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
66	381	11		
67	382	4	1258	
	383	6		
68	384	11		
69	385	4	1259	
	386	6		
70	387	11		
71	388	4	1300	
	389	6		
72	390	11		
73	391	4	1301	
	392	6		
74	393	11		
75	394	4	1302	
	395	6		
76	396	11		Misfire. Moved firing contact back and forth. Fired on second attempt.
77	397	4	1304	
	398	6		
78	396	11		
79	399	4	1306	
	400	6		
80	401	11		
81	402	4	1307	
	403	6		
82	404	11		
83	405	4	1308	
	406	6		
84	407	11		
85	408	4	1310	
	409	6		
86	410	11		
87	411	4	1312	
	412	6		
88	413	11		
89	414	4	1313	
	415	6		
90	416	11		
91	417	4	1315	
	418	6		
92	419	11		
93	420	4	1316	
	421	6		
94	422	11		
95	423	4	1319	

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
	424	6		
96	425	11		
97	426	4	1322	
	427	6		
98	428	11		
99	429	4	1323	
	430	6		
100	431	11		
101	432	4	1326	
	433	6		Misfire. The firing contact was stuck in the rearward position as a result of round 430.
102	434	11		
103	435	4	1328	
	433	6		
104	436	11		
105	437	4	1330	
	438	6		The firing contact was stuck in a rearward position.
106	439	11		
107	440	4	1331	
	441	6		
108	442	11		
109	443	4	1333	
	444	6		Firing contact stuck.
110	445	11		
111	446	4	1335	
	447	6		
112	448	11		
113	449	4	1337	
	450	6		Firing contact stuck.
114	451	11		
115	452	4	1338	
	453	6		Firing contact stuck.
116	454	11		Firing contact stuck.
117	455	4	1340	
	456	6		
118	457	11		
119	458	4	1341	
	459	6		
120	460	11		
121	461	4	1343	
	462	6		
122	463	11		

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
123	464	4	1344	
	465	6		Firing contact stuck.
124	466	11		
125	467	4	1345	Firing contact stuck.
	468	6		Firing contact stuck.
126	469	11		Firing contact stuck.
127	470	4	1346	
	471	6		
128	472	11		
129	473	4	1348	
	474	6		
130	475	11		
131	476	4	1359	
	477	6		
132	478	11		
133	479	4	1400	
	480	6		Firing contact stuck.
134	481	11		
135	482	4	1402	
	483	6		Firing contact stuck.
136	484	11		
137	485	4	1403	
	486	6		
138	487	11		
139	488	4	1405	
	489	6		
140	490	11		
141	491	4	1411	
	492	6		
142	493	11		
143	494	4	1413	
	495	6		
144	496	11		
145	497	4	1414	
	498	6		Firing contact stuck.
146	499	11		
147	500	4	1415	Firing contact stuck.
	501	6		
148	502	11		
149	503	4	1418	
	504	6		
150	505	11		Firing contact stuck.
151	506	4	1420	
	507	6		Firing contact stuck.
152	508	11		
153	509	4	1421	
	510	6		

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
154	511	11		
155	512	4	1422	
	513	6		
156	514	11		
157	515	4	1424	
	516	6		
158	517	11		
159	518	4	1425	
	519	6		
160	520	11		
161	521	4	1426	
	522	6		Firing contact stuck.
162	523	11		
163	524	4	1428	
	525	6		
164	526	11		
165	527	4	1430	
	528	6		Firing contact stuck.
166	529	11		
167	530	4	1436	
	531	6		
168	532	11		
169	533	4	1438	
	534	6		Firing contact stuck.
170	535	11		
171	536	4	1439	
	537	6		
172	538	11		
173	539	4	1440	
	540	6		
174	541	11		
175	542	4	1442	
	543	6		
176	544	11		
177	545	4	1443	
	546	6		
178	547	11		
179	548	4	1444	
	549	6		
180	550	11		
181	551	4	1445	
	552	6		
182	553	11		Firing contact stuck.
183	554	4	1446	
	555	6		
184	556	11		
185	557	4	1447	

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
	558	6		
186	559	11		
187	560	4	1448	
	561	6		
188	562	11		Firing contact stuck.
189	563	4	1449	
	564	6		
190	565	11		
191	566	4	1450	
	567	6		Firing contact stuck.
192	568	11		
193	569	4	1452	
	570	6		
194	571	11		
195	572	4	1453	Firing contact stuck.
	573	6		Firing contact stuck.
196	574	11		Firing contact stuck.
197	575	4	1455	
	576	6		
198	577	11		
199	578	4	1457	
	579	6		
200	580	11		
201	581	4	1458	
	582	6		
202	583	11		Firing contact stuck.

Date Fired: 8 February 1968.

203	584	4	1108	
	585	6		
204	586	11		
205	587	4	1110	
	588	6		
206	589	11		
207	590	4	1111	
	591	6		
208	592	11		Firing contact stuck.
209	593	4	1115	
	594	6		
210	595	11		
211	596	4	1116	
	597	6		Firing contact stuck.
212	598	11	1116	
213	599	4	1117	
	600	6		
214	601	11		

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
215	602	4	1117	
	603	6		
216	604	11		
217	605	4	1118	
	606	6		
218	607	11		
219	608	4	1119	
	609	6		
220	610	11		
221	611	4	1120	
	612	6		
222	613	11		Firing contact stuck.
223	614	4	1121	
	615	6		
224	616	11		
225	617	4	1122	
	618	6		
226	619	11		
227	620	4	1123	
	621	6		
228	622	11		
229	623	2	1126	
	624	3		
	625	4		
	626	6		
230	627	11		
231	628	15		
232	629	4	1128	
	630	6		
233	631	11		
234	632	4	1129	
	633	6		
235	634	11		Firing contact stuck.
236	635	1	1133	Misfire. Previous electrical check was satisfactory. Fired on third attempt.
	636	4		
	637	6		
237	638	11		
238	639	18		
239	640	1	1140	Misfire. Round 640 was removed from tube 1 and loaded in tube 18 and fired in ripple 244.
	641	4		

Ripple No.	Round No.	Tube No.	Time Fired	Remarks
	642	6		
240	643	11		
241	644	18		
242	645	4	1142	
	646	6		
243	647	11		
244	640	18		
245	648	4	1143	
	649	6		
246	650	11		
247	651	18		
248	652	4	1322	
	653	6		
249	654	11		
250	655	18		
251	656	4	1324	
	657	6		
252	658	11	1324	
253	659	18		
254	660	4	1325	
	661	6		
255	662	11		
256	663	18		
257	664	4	1326	
	665	6		Firing contact stuck.
258	666	11		
259	667	18		
260	668	4	1335	
	669	6		
261	670	11		
262	671	18		
263	672	4	1337	
	673	6		
264	674	11		
265	675	18		
266	676	4	1339	
	677	6		
267	678	11		
268	679	4	1340	
	680	6		
269	681	11		
270	682	4	1341	
	683	6		
271	684	11		Firing contact stuck.
272	685	6	1343	
273	686	11		

Humidity Test Firing

Ripple No.	Round No.	Tube No. 1C	Tube No. 2C	Remarks
Date Fired: 16 February 1968.				
Launcher: XM159/C Nos. 1C and 2C.				
Ammunition: Mk 40 motor, M151 warhead (inert-loaded), M423 fuze (inert-loaded).				
Mount: XM156, right side only.				
Time Fired: 1414.				
276	701	1		Misfire. Moved firing contact, fired on second attempt.
	702	2		
	703	3		Misfire. Firing contact was not touching rocket firing squib; shunted and fired.
	704	4		
	705	5		
	706	6		
	707	7		
277	708	8		
	709	9		
	710	10		
	711	11		
	712	12		
	713	13		
	714	14		
278	715	15		
	716	16		
	717	17		
	718	18		
	719	19		
Time Fired: 1430.				
279	720		1	Misfire. Moved contact; fired on second attempt.
	721		2	Misfire. Moved contact; fired on second attempt.
	722		3	
	723		4	
	724		5	
	725		6	
	726		7	
280	727		8	
	728		9	
	729		10	Misfire. Moved contact; fired on second attempt.
	730		11	Misfire. Moved contact; fired on second attempt.

Ripple No.	Round No.	Tube No. 1C	Tube No. 2C	Remarks
	731		12	
	732		13	
	733		14	
281	734		15	
	735		16	
	736		17	
	737		18	
	738		19	

Ground Firing

Ripple No.	Round No.	Time Fired

Date Fired: 20 February 1968.
Launcher: XM159/C No. 2C.
Mount: XM156, left side only.
Ammunition: Mk 40 motor, M151 warhead (HE), M423 fuze (live).
Elevation: 15°.
Tube No.: 1.

282	739	1410
283	740	1415
284	741	1420
285	742	1424
286	743	1426
287	744	1428
288	745	1430
289	746	1433
290	747	1435
291	748	1437
292	749	1439
293	750	1440
294	751	1441
295	752	1442
296	753	1444
297	754	1445
298	755	1446
299	756	1447
300	757	1448
301	758	1449
302	759	1451
303	760	1[illegible]2
304	761	1454
305	762	1455
306	763	1500

Ripple No.	Round No.	Time Fired
307	764	1502
308	765	1503
309	766	1504

Note: All rounds failed to detonate on water impact.

Aerial Firing

Ripple No.	Round No.	Tube No. 1C	Tube No. 2C	Sight Setting, mils	Time Fired	Remarks
Date Fired: 21 February 1968.						
Launcher: XM159/C Nos. 1C and 2C.						
Mount: XM156, right and left sides.						
Ammunition: Mk 40 motors; M151 warheads (inert-loaded); M423 fuzes (live with spotting charge).						
Aircraft: Helicopter, UH-1C.						
Range: 2000 meters.						
Altitude: 100 feet; hover.						
310	767		1	-40	1137	
	768	1				
311	769		2	-40	1138	
	770	4				
312	771		3	-40	1141	
	772	5				
313	773		4	-40	1143	
	774	2				
314	775		5	-40	1144	
	776	3		-	-	Misfire. Firing contact not touching rocket firing squib. Removed and loaded into tube 1 of launcher 2C.
Speed: 60 knots.						
315	777		6	+10	1146	
	778	7				
316	779		7	-20	1148	
	780	6				
317	781		8	-20	1150	
	782	18				

Ripple No.	Round No.	Tube No. 1C	Tube No. 2C	Sight Setting, mils	Time Fired	Remarks
318	783		9	-20	1152	
	784	13				
319	785		10	-25	1153	Misfire. Fired on second attempt.
	786	16				
320	787		11	-25	1155	
	788	11				
321	789		12	-25	1156	
	790	12				
322	791		13	-25	1158	
	792	9				
323	793		14	-25	1200	
	794	14				
324	795		15	-25	1201	
	796	15				
325	797		16	-25	1202	
	798	10				
326	799		17	-25	1204	
	800	17				
327	801		18	-25	1205	
	802	8				
328	803		19	-25	1207	
	804	19				
329	776		1	-25	1334	
	805	1				
330	806		2	-25	1335	
	807	4				
331	808		3	-25	1336	
	809	5				
332	810		4	-25	1337	
	811	2				
Speed:	Maximum.					
333	812		5	-35	1339	
		3				Tube left empty.
334	813		6	-35	1340	
	814	7				
335	815		7	-15	1343	
	816	6				
336	817		8	-10	1345	
	818	18				
337	819		9	-10	1346	
	820	13				

Ripple No.	Round No.	Tube No. 1C	Tube No. 2C	Sight Setting, mils	Time Fired	Remarks
Range:	3000 meters.					
338	821		10	-40	1349	
	822	16				
339	823		11	-40	1352	
	824	11				
340	825		12	-50	1355	
	826	12				
341	827		13	-50	1357	
	828	9				
342	829		14	-50	1358	
	830	14				
Range:	1000 meters.					
Speed:	60 knots.					
343	831		15	+10	1408	
	832	15				
344	833		16	+10	1409	
	834	10				
345	835		17	+10	1410	
	836	17				
346	837		18	+10	1412	
	838	8				
347	839		19	+10	1413	
	840	19				
348	841		1	+ 5	1428	
	842	1				
349	843		2	+ 5	1430	
	844	4				
350	845		3	+ 5	1431	
	846	5				
351	847		4	+ 5	1433	
	848	2				
352	849		5	+ 5	1434	Tube left empty.
		3				
353	850		6	+ 5	1435	
	851	7				Misfire. Fired on second attempt.
354	852		7	+ 5	1436	
	853	6				
355	854		8	+ 5	1438	
	855	18				
356	856		9	+ 5	1440	
	857	13				
357	858		10	+ 5	1443	

Ripple No.	Round No.	Tube No. 1C	Tube No. 2C	Sight Setting, mils	Time Fired	Remarks
	859	16				
358	860		11	+ 5	1445	
	861	11				
359	862		12	+ 5	1446	
	863	12				
360	864		13	+ 5	1448	
	865	9				
361	866		14	+ 5	1450	
	867	14				
Range: 500 meters. Altitude: 100 feet, hover.						
362	868		15	+40	1457	
	869	15				
363	870		16	+40	1458	
	871	10				
364	872		17	+40	1459	
	873	17				
365	874		18	+40	1500	
	875	8				
366	876		19	+40	1501	
	877	19				

Ground Firing

Ripple No.	Round No.	Time Fired	Remarks
Date Fired: 23 February 1968. Launcher: XM159/C No. 1C. Mount: XM156, left side only. Ammunition: Mk 40 motor; M151 warhead (HE), M423 fuze (live). Elevation: 30°. Tube No.: 1.			
367	878	1120	Motor temperature below ambient.
368	879	1123	Motor temperature below ambient.
369	880	1127	Motor temperature below ambient.
370	881	1430	
371	882	1436	
372	883	1449	
373	884	1452	
374	885	1455	
375	886	1456	

Ripple No.	Round No.	Time Fired	Remarks
376	887	1458	
377	888	1459	
378	889	1501	
379	890	1503	
380	891	1505	
381	892	1506	
Date Fired: 27 February 1968. Elevation: 15°.			
382	893	1129	
383	894	1133	
384	895	1135	Misfire. Fired on second attempt.
385	896	1139	
386	897	1141	Misfire. Fired on second attempt.
387	898	1145	
388	899	1147	
389	900	1148	
390	901	1150	
391	902	1151	
392	903	1152	
393	904	1153	
394	905	1318	
395	906	1319	
396	907	1321	
397	908	1322	
398	909	1323	
399	910	1325	
400	911	1326	
401	912	1326	
402	913	1327	
403	914	1328	
404	915	1329	
405	916	1330	
406	917	1331	
407	918	1332	
408	919	1333	

Notes: Round Nos. 893 through 899 and 901 through 919 functioned high order.
Round No. 900 failed to detonate on water impact.

Summary of Aerial and Ground Firings

Aerial Firings

Range to Target, meters	Sight Setting, deg	No. Rds Cons	Range, meters Avg	Range, meters Std Dev	Range, meters PE	No. Rds Cons	Deflection, meters Avg	Deflection, meters Std Dev	Deflection, meters PE	CEP[a]	Avg TOF, sec
Altitude: 100 feet. Speed: Hover.											
500	+40	10	548	354.7	239.2	10	+10.2	32.7	22.1	246.1	1.87
		[b] 8	394	156.6	105.6	[b] 8	- 3.2	9.0	6.1	[b]107.9	[b]1.56
2000	-40	[c] 9	2178	428.7	239.2	[c] 9	+36.2	51.2	34.5	299.7	[c]5.92
Speed: 60 knots.											
1000	+10	10	834	174.6	117.8	10	-36.6	15.7	10.6	121.1	2.20
1000	+ 5	27	959	244.2	164.7	27	-39.0	17.8	12.0	168.7	2.38
2000	+10	2	977	-	-	2	25.8	-	-	-	2.76
2000	-20	6	1740	164.0	110.6	6	5.5	21.9	14.8	115.2	4.14
2000	-25	[d]28	1970	389.5	262.7	28	-25.5	65.7	44.3	277.2	4.61
Speed: Maximum.											
2000	-35	4	2963	260.8	175.9	[c] 3	-17.2	51.3	34.6	188.0	8.03
2000	-15	2	2461	-	-	2	-48.4	-	-	-	5.96
2000	-10	4	1905	320.4	216.1	4	-53.1	25.6	17.3	221.7	4.22
3000	-40	4	2717	354.0	238.8	4	13.4	42.1	28.4	247.4	6.02
3000	-50	6	3140	227.4	153.4	6	-10.4	65.9	44.4	172.5	7.99

[a]CEP calculated from: $CEP = \sigma(1-\frac{\vee}{9})3/2$

where (1) $\sigma 2 = \sigma x^2 + \sigma_y^2$

(2) $\vee = 2\left\{\frac{\sigma x^4 + \sigma_y^4}{\sigma^4}\right\}$

Reference Statistical Measures of Accuracy for Riflemen and Missile Engineers, F. E. Grubbs, 1964.

[b]Two outliers (rounds No. 868 and 870.

[c]One round lost.

[d]Two rounds lost.

Ground Firings

Elev, deg	No. Rds Cons	Range, meters Avg	Std Dev	PE	No. Rds Cons	Deflection, meters Avg	Std Dev	PE	CEP	Avg TOF, sec
30	12	7082	80.2	54.1	12	254.0	161.2	108.7	140.7	33.26
15	27	4620	146.2	98.6	27	7.9	100.8	68.0	145.3	16.13

Round-by-Round Ballistic Data

Ripple No.	Deflection, meters	Range, meters
310	-11.2	1862.8
310	-40.9	2573.3
311	69.9	2090.6
311	13.2	2877.8
312	74.4	1543.6
312	111.8	1905.4
313	82.3	1864.4
313	33.1	2456.9
314	-6.4	2432.0
314	---	LOST
315	24.8	863.1
315	26.7	1091.7
316	-17.3	1583.3
316	-23.2	2010.4
317	31.7	1563.1
317	24.1	1812.4
318	7.8	1724.4
318	9.7	1748.1
319	19.5	2082.2
319	-34.6	1476.3
320	-56.2	1723.6
320	-99.5	2463.9
321	-56.5	1390.6
321	-35.7	1737.9
322	-46.2	2120.1
322	-63.9	2350.1
323	-85.4	2118.4
323	-93.9	2411.5
324	-62.3	1848.3
324	-93.9	2374.3

Ripple No.	Deflection, meters	Range, meters
325	9.6	1254.7
325	-21.6	1556.8
326	-23.9	1688.5
326	1.1	2615.2
327	- .7	2067.3
327	-15.4	2097.0
328	259.9	2315.1
328	23.7	2290.6
329	3.6	1299.1
329	-8.6	1934.6
330	-8.8	1664.7
330	-49.3	2137.5
331	-62.7	1973.7
331	-48.7	2584.9
332	-24.9	1493.8
332	-38.6	1940.9
333	-66.7	2670.0
333	----	2816.1 A
334	35.8	3183.3
334	-20.8	3182.4
335	-27.4	2262.0
335	-69.5	2659.6
336	-46.8	1531.2
336	-86.9	2314.1
337	-25.0	1873.7
337	-53.7	1901.6
338	-35.1	2515.2
338	-6.6	3104.0
339	37.5	2333.7
339	57.9	2913.5
340	39.5	3179.2
340	76.3	3457.0
341	8.6	2757.8
341	-31.5	3122.9
342	-107.9	3093.5
342	-47.5	3229.3

Ripple No.	Deflection, meters	Range, meters
343	-22.8	553.3
343	-34.8	1018.8
344	-6.9	975.3
344	-22.9	1012.2
345	-48.6	713.0
345	-40.3	1043.7
346	-31.6	651.3
346	-50.8	734.9
347	-51.9	758.8
347	-55.0	880.9
348	-43.1	588.0
348	-60.1	1043.3
349	-75.9	1128.0
349	-59.2	1507.8
350	-32.2	830.9
350	-30.0	1071.4
351	-52.5	1075.4
351	-46.2	1265.2
352	8.6A	1145.3A
352	-66.6	1109.0
353	-59.2	845.3
353	---	LOST
354	-23.5	788.9
354	-47.0	1189.7
355	-39.8	649.2
355	-43.6	870.8
356	-33.1	865.4
356	-23.4	1232.8
357	-23.3	837.3
357	-42.9	1349.0
358	-31.3	602.8
358	-30.5	743.1
359	-14.9	701.6
359	-19.9	1100.4

Ripple No.	Deflection, meters	Range, meters
360	-48.9	643.7
360	-44.2	824.5
361	-28.8	736.9
361	-40.6	1089.0
362	-6.6	323.9
362	33.9	1063.1
363	4.9	699.5
363	94.1	1259.4
364	1.5	208.1
364	-21.3	314.1
365	-5.9	437.9
365	-7.0	486.4
366	2.6	250.7
366	5.8	433.4

"A" Indicates "Approximate"
"-" After Deflection Indicates "Left"

ROUND-BY-ROUND BALLISTIC DATA

Ripple No.	Deflection, meters	Range, meters
370	-86.2	7219.7
371	214.2	7180.5
372	267.3	7058.2
373	169.3	7006.8
374	431.9	7000.4
375	332.5	6947.4
376	146.3	7083.7
377	324.7	7051.9
378	116.1	7082.5
379	311.6	7094.1
380	276.5	7078.5
381	543.7	7182.7
382	-103.3	4707.6
383	-69.0	4798.5
384	-51.9	4449.4
385	6.4	4230.7
386	-172.2	4495.5
387	-42.9	4703.7
388	-89.1	4600.0
389	-90.8	4689.5
390	-49.5	4393.7
391	-86.9	4708.9
392	-69.4	4795.6
393	-122.5	4541.9
394	36.0	4846.0
395	7.1	4668.8
396	121.4	4740.8
397	70.7	4700.1
398	-70.7	4665.7
399	58.7	4576.6
400	17.0	4603.9
401	112.8	4413.3
402	-53.4	4544.6
403	128.5	4572.5

Ripple No.	Deflection, meters	Range, meters
404	105.5	4890.7
405	111.6	4584.6
406	178.9	4655.0
407	156.5	4536.0
408	165.1	4630.8

APPENDIX II - FINDINGS

Requirements	Source, Applicable Tech Req for XM158 Rocket Launcher, Par. No.	Findings	Test Par. No.
Human factors design criteria shall conform to specifications on human factors. The design shall be compatible with the use of arctic mittens.	3.1.2.2	Satisfactory. The use of arctic mittens produced the normal inconviences.	2.6
The electrical design will be in conformance to MIL-M-11991B.	3.1.2.3	Satisfactory.	2.2
Metals shall be of the corrosion-resistant type or suitably treated to resist corrosion due to rocket blasts, fuels, salt spray, or atmospheric conditions likely to be met in storage or normal service.	3.1.2.4	Unsatisfactory. The firing contact and support assembly were subject to corrosion.	2.3, 2.6
One complete reuseable 19-tube launcher shall not weigh more than 130 pounds in flight configuration.	3.1.2.5	Satisfactory.	2.2
The 19 tubes shall be clustered in a minimum volume package which shall be essentially cylindrical.	2.1.2.6	Satisfactory.	2.2

Requirements	Source, Applicable Tech Req for XM158 Rocket Launcher, Par. No.	Findings	Test Par. No.
The 19-tube launcher shall be serviceable during and after being repeatedly subjected to g factors, shock, and vibration when attached to the XM156 subsystem support structure in UH-1B helicopter flight and ground environment. This applies to launchers that are empty, partially filled, and completely filled with 2.75-inch rockets.	3.1.2.7	Unsatisfactory. Rocket-detent failures were experienced during the vibration test.	2.3
Electrical power for firing rockets and jettisoning shall be drawn from the aircrafts 24- to 28-volt d-c system under operational conditions.	3.1.2.8	Satisfactory.	2.2
The reuseable 19-tube launcher shall be capable of being attached to the MA-4A bomb rack. The external electrical plug shall be set in line with the launcher bomb rack eye hooks on the launcher fore end where bomb rack sway braces and launcher external wiring will not interfere with each other. The electrical plug shall have a dust cover.	3.1.2.9	Satisfactory.	2.2

Requirements	Source, Applicable Tech Req for XM158 Rocket Launcher, Par. No.	Findings	Test Par. No.
Hard point surfaces to accommodate the use of sway braces shall be provided. These surfaces shall as a minimum be compatible with the sway brace locations of the XM156 subsystem.	3.1.2.10	Satisfactory.	2.2
The launcher, including the bomb rack attachments and sway brace surfaces and including when it is loaded with 19 rockets weighing as much as 21.5 pounds each, shall be designed to withstand at least 4 g's forward, 5 g's downward, 2 g's upward, and 1.5 g's lateral applied individually. The launcher shall also be designed to withstand combined loads of at least 3.6 g's downward, 1.82 g's aft or 1.82 g's forward, and 0.62 g outboard or 0.62 g inboard.	3.1.2.11	Unsatisfactory. Rocket-detent failures were experienced during the vibration test.	2.3
The launcher shall have 19 essentially round tubes which are nominally 60 inches long. The outside diameter of the launcher shall be approximately 15.5 inches.	3.1.2.12	Satisfactory.	2.2

Requirements	Source, Applicable Tech Req for XM158 Rocket Launcher, Par. No.	Findings	Test Par. No.
The rocket detent shall not incorporate any item which must be replaced for each rocket firing. The detent shall require a 100-pound minimum force applied before release of the rocket.	3.1.2.13	Satisfactory.	2.2
A minimum of combustible material shall be used in the launcher construction. Any combustible material shall have a minimum of exposure to the rocket blast fire and hot gases and shall be treated with fire-retardant chemicals so no burning or smoldering will occur.	3.1.2.14	Satisfactory.	2.2
The launcher shall be capable of withstanding a firing rate of approximately 6 rounds per second.	3.1.2.16	Satisfactory.	2.3
The Armament System fire control arrangement and wiring to be used with the reuseable 19-tube launcher and the wiring of the launcher itself shall be such that rockets are not fired successively from adjacent tubes.	3.1.2.17	Satisfactory.	2.2

Requirements	Source, Applicable Tech Req for XM158 Rocket Launcher, Par. No.	Findings	Test Par. No.
The electrical wiring shall be as follows: The design and construction shall insure that all external launcher parts exclusive of transmission line terminals are at ground potential at all times in accordance with ABMA-STD-54C. All firing circuits contained in the launcher shall be shielded. All shields shall be connected and grounded. The shields shall make contact with the metallic components of the launcher.	3.1.2.19	Unsatisfactory. The firing-circuit shielding is not connected to the metallic components of the launcher.	2.2
Special tools shall not be required for maintenance of the reuseable 19-tube launcher. High failure parts of the launcher shall be removeable and replaceable by field maintenance.	3.1.2.20	Unsatisfactory. The rocket-motor detent has a high failure rate when subjected to vibration, but it cannot be replaced.	2.2
The reuseable launcher shall not be used for transportation or storage of rockets.	3.1.2.21	Satisfactory.	2.2

Requirements	Source, Applicable Tech Req for XM158 Rocket Launcher, Par. No.	Findings	Test Par. No.
No seals will be required to protect the launcher against the applicable environmental conditions of AR 705-15 W/C1 during transportation, storage, and service use. No aerodynamic fairings, neither fore or aft, nor individual tube end closures are required during service life.	3.1.2.22	Satisfactory.	2.6
The launcher shall perform its functions after and during exposure (as applicable) to environmental conditions defined in AR 705-15, W/C1 with the exception of paragraph 7e, Extreme Cold Climatic Conditions.	3.1.3	Unsatisfactory. The wiring-harness resistance and continuity was erratic after the humidity and salt-spray tests.	2.6
The launcher shall be compatible with 2.75-inch folding fin aircraft rockets having the standard warhead M151 (10-pound) with the M423 fuze. The launcher shall be compatible with the XM156 subsystem.	3.1.4	Satisfactory.	2.4
The reuseable 19-tube launcher shall meet all the applicable test requirements of specification MIL-STD-810.	4.1	Unsatisfactory. The wiring-harness resistance and continuity were erratic after the humidity, salt spray, and vibration tests.	2.6

Requirements	Source, Applicable Tech Req for XM158 Rocket Launcher, Par. No.	Findings	Test Par. No.
The launcher must meet the desired accuracy requirements for the 2.75-inch rocket.	QMR, par. 7d(2)	Unsatisfactory.	2.5
The peak and steady-state currents required by the test items, when added to the normal loads imposed on the aircraft electrical system, shall not exceed the capability of the aircraft primary electrical system.	Devised by D&PS.	Satisfactory.	2.3, 2.6, 2.8
The XM159/C launcher shall be capable of firing a minimum of 25 (35 desired) rounds from each launcher tube without parts or tube replacement.	Ltr, AMCPM-AI, 19 Jan 1967	Satisfactory.	2.4
The XM159/C rocket launcher must complete all phases of testing without exhibiting one unsafe condition.	Devised by D&PS.	Unsatisfactory. Rocket-detent failures encountered during flight can jam and hold a firing rocket motor. The firing-circuit shielding is not connected to the metallic components of the launcher.	2.4

APPENDIX III - DEFICIENCIES AND SHORTCOMINGS

1. Deficiencies

Deficiency	Suggested Corrective Action	Remarks
The rocket-motor detents failed during the vibration test (par. 2.3).	Increase the strength of the detent.	The detents failed while vibrating rockets with the XM229 warhead and also the M151 warhead. Broken detents have jammed the rocket in the tube so that, if the motor was fired, the rocket would not be immediately released.
The firing-circuit shielding is not connected with any metallic components of the launcher (par. 2.2, and 2.7).	Connect the shielding to the metallic components of the launcher.	The ungrounded shielding could result in firing a rocket motor by induced current if the electrical cable between the mount and launcher is not connected.
The wiring-harness continuity was erratic depending on movement of the firing contact (par. 2.3, 2.4, 2.6, and 2.7).	Redesign the firing circuit so that the firing lead connects directly to the firing contact instead of the spring-loaded rod which is only pin-connected to the firing contact.	No positive electrical connection exists. When continuity does not exist, the rocket firing squib is not shorted and is subject to firing as a result of induced current.
The design of the rocket detent does not insure immediate release of the firing rocket (par. 2.7).	Provide a force-release detent or modify the 2.75-inch rocket to insure simultaneous release of the nozzle closures.	The present design decreases accuracy and results in a potential safety hazard.

2. Shortcomings

Shortcoming	Suggested Corrective Action	Remarks
Excessive corrosion occurred on and around the firing contact, and four contacts corroded so that they could not be moved (par. 2.3).	Change the materials or provide a protective coating to eliminate the corrosion.	
The firing contact failed to reliably return to the forward position after firing (par. 2.4).	Modify the firing-contact assembly.	
The distance between the firing contact and the rocket detent in one tube was too great to provide electrical continuity (par. 2.6).	Improve the contractor's quality-control program.	
The launcher did not meet the desired accuracy requirements for the 2.75-inch rocket.	Improve the accuracy of the rocket.	

APPENDIX IV - MAINTENANCE EVALUATION

The XM159/C rocket launcher requires limited maintenance. The launcher tubes must be cleaned after firing to prevent corrosion. The spring-loaded firing contacts require a lubricant which will also ensure an adequate electrical continuity between the firing contact and the mounting bracket.

Handling of the empty launchers (transporting from one location to another and mounting and dismounting from the aircraft) should be done with care to avoid dropping. The cowling cover, which is 0.040-inch-thick aluminum, is easily punctured and the aluminum structure is susceptible to breakage and cracking. Under no conditions should the loaded launcher be transported, except when attached to an aircraft mount by the lugs.

APPENDIX V - CORRESPONDENCE

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DEPARTMENT OF THE ARMY

HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND

ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-BG
4-4-1542-07/08/09 30 MAR 1966

SUBJECT: Test Directive, Engineering and Service Test of XM159 Pod for 2.75 Inch FFAR

TO: Commanding Officer, Aberdeen Proving Ground, ATTN: STEAP-DS-TI, Aberdeen Proving Ground, Maryland 21005
Commanding Officer, U. S. Army Aviation Test Activity, ATTN: STEAV-CO, Edwards Air Force Base, California 93523
President, U. S. Army Aviation Test Board, ATTN: STEBG-PR, Fort Rucker, Alabama 36362

1. References:

a. Letter, AMSTE-BG, dated 7 January 1966, subject: Armed and Armored CHINOOK - Safety Release and Weapons Verification Testing, USATECOM Project No. 4-5-2010-06/07.

b. RDT&E Project 1X141806D134-04, AMCMS Code 5142.12139.04.

2. Background: To meet a need for additional armament systems with a large capacity of 2.75" rockets, it is proposed to utilize two XM159, 19-tube rocket pods with components of the XM16/XM21 armament system on the UH-1B helicopter. The XM159 pod is currently being tested on the CH-47A aircraft in accordance with the requirements of the reference letter. In that test on two occasions the rocket failed to leave the tube when fired. The cause was not determined since the pods were jettisoned and lost. However, this emphasized two differences from the XM-3 launcher.

a. The rocket motor is restrained from rotating, requiring a secure attachment of the warhead to keep it from unscrewing due to vibration.

b. The rocket is released by pressure from the motor gas acting on detent.

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3. Description of Materiel: The XM159 is a 19-tube pod for the 2.75" FFAR. It is a modification of the Air Force LAU-3B/A pod with the intervalometer removed. For the UH-1B application the intervalometer will be located in the helicopter. The pod is suspended from the MA4A bomb rack portion of the XM16 or XM21 armament system. The machine guns and turrets are removed from the system to stay within weight limitations.

4 Test Objective: The objective is to evaluate the pod for suitability in this application. The objective is divided into two phases as follows:

a. Conduct sufficient tests to allow limited production action on the pods for this application. (Phase A)

b. Supplement with the additional tests necessary for Standard A action on the pods for this application. (Phase B)

5. Responsibilities: Each agency is responsible for preparing a plan, conducting tests, and writing a report.

a. APG is responsible for the engineering test of the pod in all areas except those specified for ATA.

b. ATB is responsible for the service test of the pod.

c. ATA is responsible for engineering tests of the pod with respect to stability, control, performance, and handling characteristics of the aircraft with the pod installed. This should include investigation of the safe jettison flight envelope.

6. Coordination: Informal coordination should be made between each agency to assure compatibility of test plans and eliminate all duplication. Following this, each agency is requested to coordinate by providing draft copies of the test plans with requests for written comments to the following:

a. U. S. Army Combat Developments Command Aviation Agency, Fort Rucker, Alabama.

b. U. S. Army Weapons Command, Rock Island Arsenal, ATTN: AMSWE-RDW, Rock Island, Illinois.

c. U. S. Army Aviation Command, ATTN: SMOSM-W, St. Louis, Missouri.

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30 MAR 1966

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d. U. S. Army Missile Command, ATTN: AMXMI-XBT, Redstone Arsenal, Alabama.

Comments should be documented in the test plans submitted to this Headquarters.

7. Special Instructions:

a. Limited Production action for these pods is planned. Therefore, each agency should plan to have the first phase of the testing completed as soon as possible. This program carries a priority designator of 02. It has a USATECOM priority of 2 as an MUL test project. The following estimated requirements have been submitted to U. S. Army Materiel Command:

AGENCY	FUNDING	TIME MONTH	NO. OF PODS
APG & ATB			
Phase A	$89,000	2	8
Phase B	$34,000	1	5
ATA	$10,000	2 1/2	4 (firing) 24 (jettison)

Tests should be designed to require only the minimum essential number of 2.75" rockets because of their critical supply status. An estimate of requirements should be submitted to this office by 25 April 1966.

b. The following USATECOM Project No.'s have been assigned and entered into the TSMS:

(1) APG 4-4-1542-07

(2) ATB 4-4-1542-08

(3) ATA 4-4-1542-09

c. It is requested that all aerial firing of APG engineering tests and ATB service tests be conducted on an integrated basis at APG.

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30 MAR 1966

AMSTE-BG
4-4-1542-07/08/09
SUBJECT: Test Directive, Engineering and Service Test of XM159 Pod for 2.75 Inch FFAR

8. Test Plans and Reports:

a. APG is requested to submit a plan for the engineering test by 15 June 1966. An interim report of tests sufficient for LP action is desired 40 working day following start of test. The final report is desired 30 working days after all testing is completed.

b. ATB is requested to submit a plan for the service test by 15 June 1966. An interim report of tests sufficient for LP action is desired 40 working days following start of test. The final report is desired 22 working days after all testing is completed.

c. ATA is requested to submit a plan for the engineering flight test by 15 June 1966. The final report is desired 30 working days after the testing is completed.

9. Safety: The Aviation Command is in the process of obtaining data for a safety-of-flight release for this system. ATA is requested to coordinate with AVCOM and be prepared to comment on the safety-of-flight release. The safety-of-flight release is required prior to flight tests by APG and ATB. APG is requested to submit a preliminary report on safety limitations to apply to service test operations, not later than 30 days after commencement of the engineering test. This should be followed by a supplemental report of a safety release in accordance with USATECOM Regulation 385-6. Since the flight testing for engineering and service tests is to be conducted on an integrated basis, service testing may commence in the absence of a safety release, utilizing safety procedures for an engineering test until adequate information is obtained to issue a safety release. A statement on safety confirmation in accordance with USATECOM Regulation 385-7 should be contained in the service test report.

10. Security: This item is unclassified.

FOR THE COMMANDER:

/s/ David M. Kyle
/t/ DAVID M. KYLE
Colonel, GS
Dir, Avn Mat Testing

2 Incl w/d
1. TSMS Form
2. Distribution list

Copy furnished:
CG, USAMC, AMCPM-AI

DEPARTMENT OF THE ARMY
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-BG
4-4-1542-07

29 NOV 1967

SUBJECT: ET of 2.75" Rocket Launcher, XM159C

TO: Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-DS-TI

1. References:

a. Letter, AMSTE-BG, 25 August 1967, subject: Engineering Test Plan of Rocket Launcher XM159B.

b. Letter, AMCPM-AI, 21 November 1967, subject: ET/ST, 2.75" Rocket Launcher XM159C. (Incl 1)

c. Letter, AMSMI-IQT, 16 November 1967, subject: Initial Production Test Plan for the XM157B and XM159C, 2.75-Inch Rocket Launcher. (Incl 2)

2. Reference 1a approved the ET plan submitted by your agency for the XM159B Rocket Launcher.

3. References 1b and 1c indicate there is no planned procurement for the XM159B and reference 1b requests that ET/ST be conducted on the XM159C.

4. In accordance with reference 1b the following direction is provided:

a. Launcher to be tested is of the latest design which includes a laminated bulkhead, spring loaded contact points and length has been increased to approximately 58 inches.

b. Test plan approved in reference 1a will be modified to reflect the changes necessary to properly identify the item as the XM159C and to indicate that firings to be conducted will be with the XM229 warhead.

29 NOV 1967

AMSTE-BG
SUBJECT: ET of 2.75" Rocket Launcher, XM159C

c. Testing is to be initiated as soon as possible, utilizing the two XM159C launchers presently available at your agency. Additional launchers will be available in early December.

d. Start of test is not contingent upon approval of modified test plan.

e. Combined tests which satisfy both ET and IPT requirements will be used to the maximum extent possible.

FOR THE COMMANDER:

Richard H Miller
for RAYMOND E. JOHNSON
Colonel, GS
Dir, Avn Mat Testing

2 Incl
as

Copies furnished:
CG, USAMICOM, AMSMI-XBT
CG, USAMC, AMCPM-AI
Proj Mgr for 2.75 " Rkt,
AMCPM-RK, Dover, N.J.
Pres, ATB, STEBG-TP

DEPARTMENT OF THE ARMY
HEADQUARTERS UNITED STATES ARMY MISSILE COMMAND
REDSTONE ARSENAL, ALABAMA 35809

JUL 1 - 1968

IN REPLY
REFER TO

AMSMI-RT

SUBJECT: Vibration of XM-157B Rocket Launcher

TO: Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-DS-TI, Lt. Boyle
Aberdeen Proving Ground, Maryland 21005

1. On 23 March 1968, a vibration test was performed on an XM-157B, 2.75-inch rocket launcher. The test specimen was the second such unit received in the Aircraft Armament vibration program, which was conducted by Test and Reliability Evaluation Laboratory, R&DD, USAMICOM in support of Development and Proof Services, USATECOM.

2. The test setup included a pylon used to attach external stores to the UH-1B helicopter, an XM-156 mount, and the XM-157B launcher. Rockets composed of inert MK40 motors, inert M-151 warheads, and inert M-423 fuzes were used to load the launcher. Rocket weight was approximately 20.5 pounds each.

3. The vibration input was a laboratory simulation of a helicopter flight environment, in accordance with MIL-STD-810B, Figure 514-1, curve M. The high frequency input was reduced to 2.5 g peak, which is permitted by the standard for items weighing over 75 pounds. The test time required was three hours in each of the major orthogonal axes, including sweeps and resonant dwells. A 30-minute dwell was to be performed at each resonant frequency of the test item, up to a maximum of four. The remaining time was to be spent in sweeps.

4. With the vibration input in the longitudinal axis, the launcher was subjected to two hours of swept vibration, plus one hour of resonant dwells. The first resonance was found at 23 H_z, but shifted to 34 H_z during the 30-minute dwell. The second dwell was at 494 H_z. Throughout the test, the launcher was loaded with seven inert rockets, as described above. On removing the rockets at the end of the test, all seven rocket detents in the launcher were found to have broken during the vibration exposure.

JUL 1 - 1968

AMSMI-RT
SUBJECT: Vibration of XM-157B Rocket Launcher

5. Due to the detent failure, the vibration tests in the vertical and transverse axes were cancelled.

FOR THE COMMANDER:

WILLIAM P. LLOYD
Director
Test & Reliability Evaluation Lab, R&DD

APPENDIX VI - REFERENCES

1. Comer, Herbert D., Second Revision of Test Plan on Engineering Test of Pod, XM159/C, For Rocket, 2.75-Inch, LSFFAR. USATECOM Project No. 4-4-1542-07. Aberdeen Proving Ground, August 1967.

2. Jamison, H. M., Test of: Two Launchers, Rocket, 2.75-Inch, XM159/C, Nos. 1C and 2C, Engineering Measurements and Analysis Division, Physical Test Branch. Aberdeen Proving Ground Report No. 68-L-162, 12 June 1968.

3. Jamison, H. M., Test of: Launcher, Rocket, 2.75-Inch, XM159/C, No. 4C, Engineering Measurements and Analysis Division, Physical Test Branch. Aberbeen Proving Ground Report No. 68-L-132, 9 May 1968.

4. Garrard, P. H., Test Report Aircraft Armament Vibration. Redstone Arsenal Report No. RT-TM-68-14, 28 May 1968.

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Final Report on USATECOM Project No. 4-4-1542-07, Engineering Test of Launcher, XM159/C, for Rocket, 2.75-Inch, LSFFAR, October 1968

RDT&E Project No. 1X141806D134-04, Report No. DPS-2884

Author Frederick W. Boyle

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83 pages, 2 illustrations

Unclassified Report

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The engineering test of the XM159/C rocket launcher was conducted at Aberdeen Proving Ground, Maryland from December 1967 through 16 July 1968. Environmental tests, including simulated helicopter vibration, rain, temperature-humidity, salt spray, sand and dust, and high and low temperature, were conducted. The primary objective of the test was to evaluate the launcher for suitability for use on the UH-1 series helicopter. The test results revealed deficiencies in the electrical firing-circuit design, the ability of the launcher to withstand the aircraft vibration test, and the gas impingement principle of operation of the rocket-motor detent. Shortcomings included excessive corrosion on and about the firing contact, the failure of the firing contacts to reliably return to the forward position after firing, inadequate quality control during manufacturing, and the failure to meet the accuracy requirements. The XM159/C rocket launcher, as designed, is not considered suitable for the intended use. It is recommended that the launcher be improved to correct the deficiencies and shortcoming noted in this report.

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14 KEY WORDS	LINK A		LINK B		LINK C	
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Pod						
Rocket launcher						
Launcher						
Electrical firing circuit						
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